International Journal of Agricultural Science and Research (IJASR)
ISSN(P): 2250-0057; ISSN(E): 2321-0087
Vol. 7, Issue 4, Aug 2017, 547-554

ESTIMATING THE WATER BALANCE COMPONENT IN RANGMATI RIVER BASIN USING SWAT MODEL

HINA BHATU[1] & HARJI RANK[2]

[1]*Assistant Professor, Department of Agriculture, School of Engineering, RK University, Rajkot, India*

[2]*Research Engineer, AICRP on Irrigation Water Management, Junagadh Agricultural University, Junagadh, India*

ABSTRACT

It is necessary to understand the quantity and quality in space and time to utilize water resources in a sustainable manner. The soil and water assessment tool (SWAT) is used for estimating water balance component. The total 518 km² area of river basin was subdivided into 7 sub watershed and 230 hydrologic response units (HRUs). The average of mean seasonal and annual water balance component showed that seasonal rainfall, seasonal runoff, seasonal groundwater recharge and seasonal ground water recharge was found increasing at 75.65 mm/decade, 47.32 mm/decade, 10.91 mm/decade and 12.10 mm/decade respectively while seasonal potential evapotranspiration and annual potential evapotranspiration was found as decreasing at 4.76 mm/decade and 2.71 mm/decade respectively.

***KEYWORDS:** SWAT Model, Rangmati River Basin, Groundwater Recharge, Evapotranspiration, Rainfall & Runoff*

Received: Jun 22, 2017; **Accepted:** Jul 08, 2017; **Published:** Jul 31, 2017; **Paper Id.:** IJASRAUG201771

Original Article

INTRODUCTION

Water is truly a unique gift to mankind from the nature. The population growth in India is 2% per year. It is essential that the food production should increase by about 2.5% per year (to allow for higher food intake). Irrigated area should be increased and the potential productivity of crop should be realized to the maximum possible extent. It is estimated that 70% of urban and 30% of rural water requirement would be met from surface water sources and the remaining from groundwater resources [7]. It is necessary to understand the quantity and quality in space and time to utilize water resources in a sustainable manner. The soil and water assessment tool (SWAT) is used in this study. The SWAT model is a comprehensive, semi-distributed, process based catchment model [1]. The implemented process representations are simplifications of reality [5] which are constantly improved [1]. These simplifications of reality (e.g., hydrologic response units are not spatially identified within a sub-basin) make SWAT a computationally efficient model, which is capable of continuous simulation over long time periods [5]. [1] Highlights SWAT's flexibility in combining upland and channel processes and the simulation of land management as fundamental strengths of the model.

The study was planned for the delineating the different watersheds using Remote Sensing and GIS, estimating the runoff, evapotranspiration and groundwater recharge by SWAT model. It will help prepare a future plan for the water resources development and management for the basin.

MATERIALS AND METHODS

Description of Study Area

Jamnagar is a city, located on the western coast of India in the state of Gujarat in Saurashtra with 22.40° N latitude and 70.14° E longitude. The total area of the district is 10,074 km^2 having 6 Taluks. The major parts of area of this district are plain with the hills of Bardo, Alech and Dales. Major central part of the area is occupied by Deccan basalt, western part by marine Tertiary rocks, northern and western coastal area by Quaternary sediments. In general, ground water in Deccan basalt is fresh whereas in Tertiary and Quaternary sediments it is brackish due to inherent salinity as well as sea water intrusion. Miliolite limestone in this area forms good aquifer [2]. It is connected to the coastal belt area, of which the land is saline. Its coastline is 355 km long. The eastward and westward lands of the district are fertile. Jamnagar has a hot semi-arid climate. The "hot" season is from March to May and is extremely hot and dry, before giving way to the "wet" season with extremely erratic monsoonal rainfall that averages around 630 mm (25 in) but has varied from less than 100 mm (3.9 in) in 1911 and 1939 to over 1,500 mm (59.1 in) for the district in 2010.Tropical cyclones sometimes affect the region during this period. The "cool" season from October to February remains hot during the day but has negligible rainfall, low humidity and cool nights.

This district has no perennial flowing rivers, but the Bhagedi, Phoolzar, Aji, Venu, Demi, Nagmati, Rangmati, Sasoi, Kankavati, Und rivers flow for hours after storm during monsoon season. All these rivers may be considered as the small drainage channels in comparison to the large rivers of the state. The biggest river in this district has a maximum width of 600 feet. These rivers become dry within 10 to 15 days after rainfall season. Dams have been constructed on the river Sasoi, Venu and Und from which, the facility for water supply is provided. Rangmati river originates from near Rampar (Ta: Lalpar) and meets in Arebian sea near Bedi. Its length is 50 km with 518 km^2 catchment area. Rangmati dam is situated on this river having 70 km^2 catchment areas.

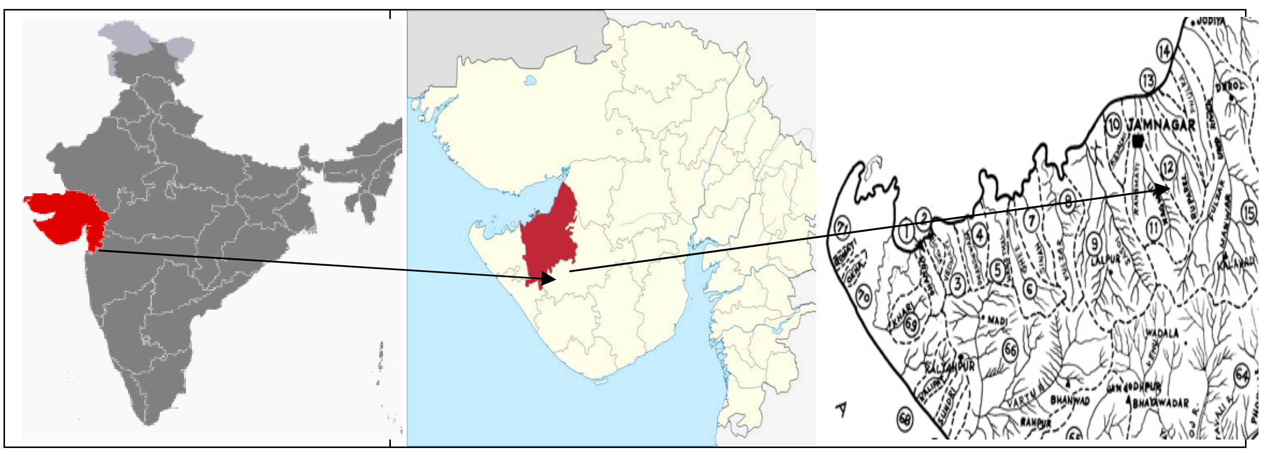

Figure 1: Location Map of Study Area

Required Data for SWAT

The Soil and Water Assessment Tool (SWAT) model is a physically based, spatially semi-distributed and computationally efficient model that can be used to simulate a single basin or a system of multiple basins that are hydrologically connected [6]. It is a continuous time series model with a GIS interface and that uses readily available input data. Basic input information required for modelling a river basin in SWAT include a digital elevation model, soil, land use

and climate data. SWAT uses the topographic data to divide a river basin into multiple sub-basins, which are further subdivided into hydrologic response units (HRUs) that consist of homogeneous land use, management, and soil characteristics [5].

Data used for setting up the SWAT model for the river basin included a digital elevation model (DEM), soil and land-use maps, data on soil properties were collected from BISAG, Gandhinagar. Daily climate data from 4 weather stations spread within and around the River Basin were used as the climate input to the SWAT model. The observed data were obtained from the State Water Data Centre (SWDC), Gandhinagar and Millet research station. JAU, Jamnagar. The future weather data was obtained through [3] and [4]. Some of the weather stations might have missing data in their records, which might be filled using the WXGEN weather generator model offered in SWAT. The WXGEN model requires long-term statistics of rainfall, minimum and maximum temperature to be able to fill in missing data. Long term climate statistics were used for generating missing data in the climate records. The collected data was bias corrected developing programme in excel spreadsheet. Bias corrected data were used as input data for SWAT model.

RESULTS AND DISCUSSIONS

The water balance components like runoff, evapotranspiration and groundwater recharge was estimated through the simulation of the SWAT model for the weather data of 40 years (1961-2000-control scenario), 19 years (2046-2064-future scenario) and 20 years (2081-2100-future scenario). During the SWAT model simulation, it was found that the basin is divided into 230 HRUs. The total number of the sub watersheds of the basin was found as 7. Water balance components estimated by SWAT for Rangmati basin during control scenario (1961-2000), future scenario (2046-2064) and future scenario (2081-2100) are shown in figure 1, 2 and 3, Respectively.

Rainfall and Runoff

The daily runoff was obtained from the SWAT run simulation results using the daily rainfall data. The average rainy season rainfall and runoff estimated respectively 444 mm and 182 mm during the period 1961-2000, 729.86 mm and 366.66 mm during the period 2046-2064, 1347 mm and 745 mm during the period 2081-2100 in the basin. The rainfall along with runoff obtained by SWAT model during the different scenarios (1961-2000, 2046-2064 and 2081-2100) was compared graphically in Figure 4. The overall scenario (1961-2100) showed that the Rainy Season rainfall and runoff will be increased @ 72.5 mm/decade and 44.36 mm/decade in the future. These can increase the water resources of the basins.

Evapotranspiration

The potential and crop evapotranspiration during the rainy season were estimated for the different years by the SWAT model. The input data fed to the SWAT model were daily maximum and minimum temperature and daily rainfall values. The average potential evapotranspiration and crop evapotranspiration during the Rainy Season was found as 1107.37 mm and 170.84 mm during the period 1961-2000, 1054.14 mm and 211.28 mm during the period 2046-2064, 1059.78 mm and 316.80 mm during the period 2081-2100, respectively. The potential evapotranspiration has decreasing trend during the period 1961 to 2000 while crop evapotranspiration is increasing. The reason is that the amount of monsoon seasonal rainfall is found in increasing trend during 1961 to 2000 which increased the moisture status during the monsoon season. But in future scenario (2046-2064, 2081-2100) the potential evapotranspiration and crop evapotranspiration will be increasing. This may be due the increased temperature due to global warming. The overall scenario (1961-2100) showed that the Rainy Season potential evapotranspiration and crop evapotranspiration will change

at 12.06 mm/decade and -50.0 mm/decade in the future (figure 5). These can increase the water resources of the basin. The decrease in the potential evapotranspiration and increase in the crop evapotranspiration may be due the increase in the rainfall.

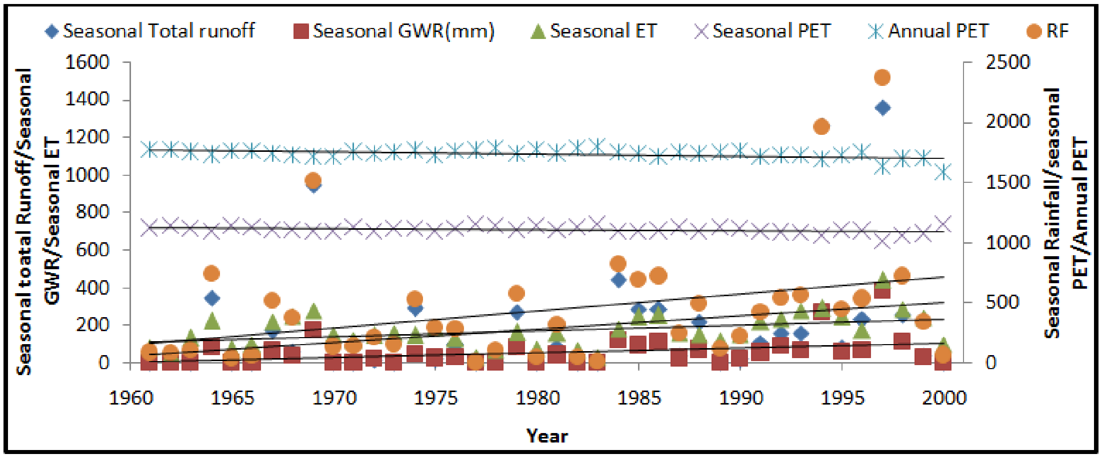

Figure 2: Water Balance Components Estimated by SWAT for Rangmati Basin during Control Scenario (1961-2000)

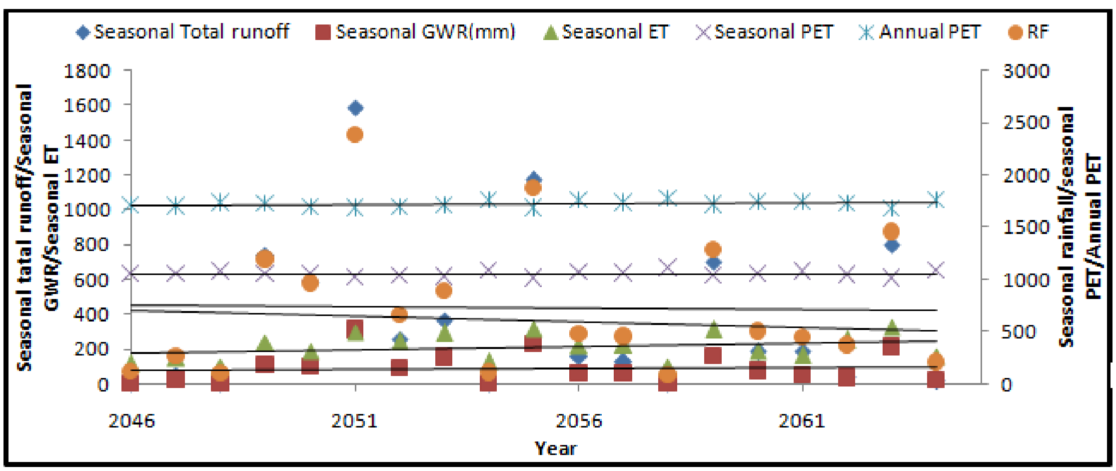

Figure 3: Water Balance Components Estimated by SWAT for Rangmati Basin during Control Scenario (2046-2064)

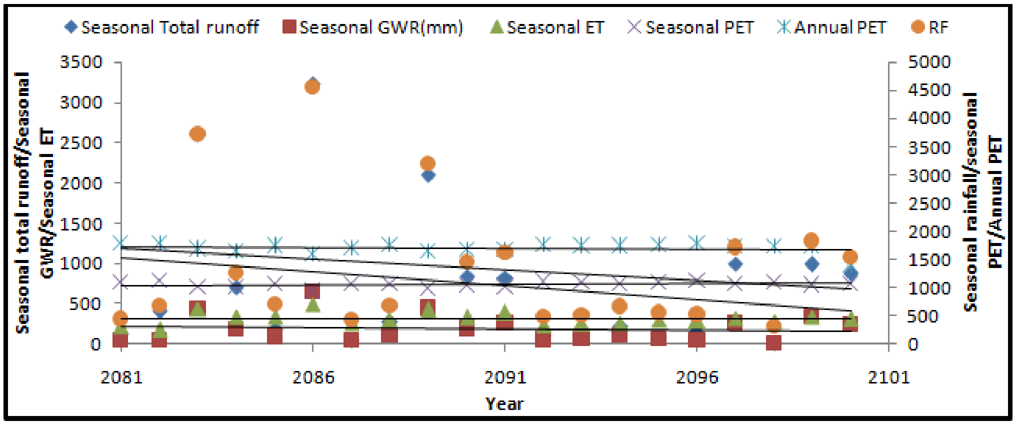

Figure 4: Water balance components estimated by SWAT for Rangmati basin during control scenario (2081-2100)

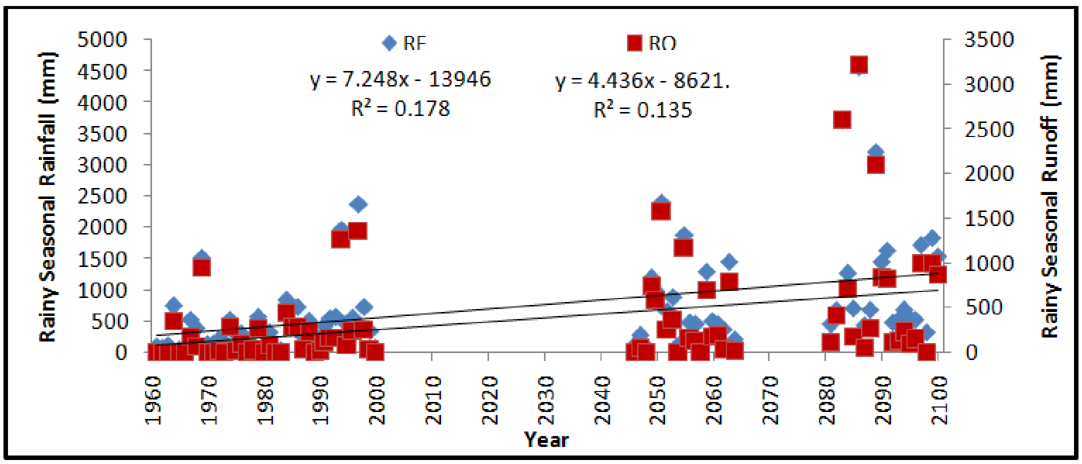

Figure 5: Comparison of Rainfall and Runoff Variations in Rangmati Basins During different Scenarios (1961-2000, 2046-2064, 2081-2100)

Groundwater Recharge

The average groundwater recharge during the rainy season was found as 55.89 mm, 89.52 mm and 188 mm during the period 1961-2000, 2046-2064 and 2081-2100, respectively by SWAT model. Also the groundwater recharge was estimated by Krishna Rao (1970) approach 621.4 mm, 108.76 mm and 277 mm during the period 1961-2000, 2046-2064 and 2081-2100, respectively. The overall scenario (1961-2100) showed that the Rainy Season groundwater recharge will change increase at 17.5 mm/decade in the future as per the Krishna-Rao (1970) estimation (figure 6). There can be increase in the groundwater resources of the basin due to increasing rainfall in the future. However, the groundwater recharge by SWAT model showed a stable trend.

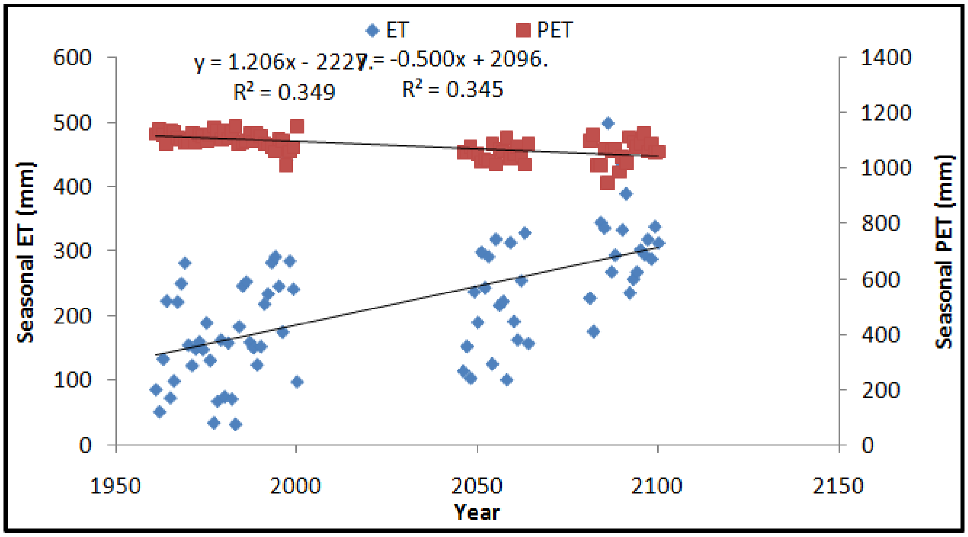

Figure 6: Comparison of Potential Evapotranspiration and Crop Evapotranspiration Variations in Rangmati Basin During different Scenarios (1961-2000, 2046-2064, 2081-2100)

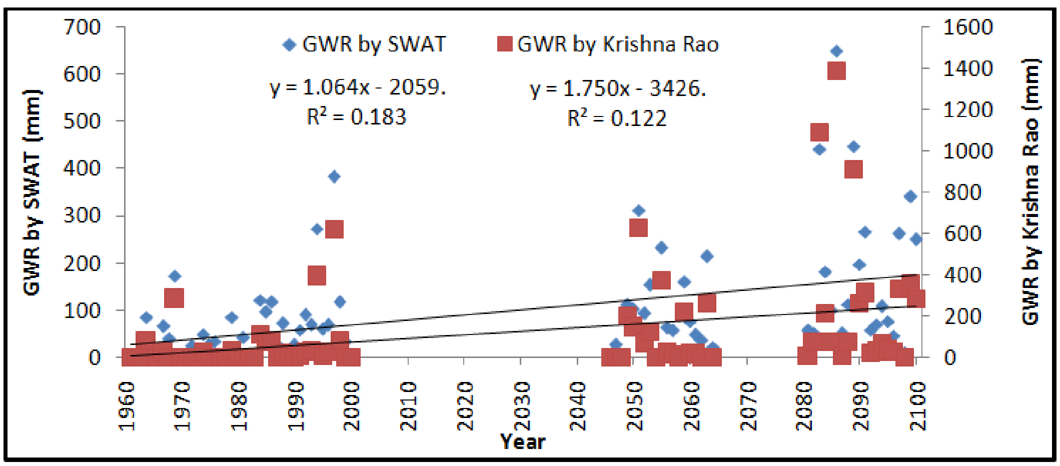

Figure 7: Comparisons of Groundwater Recharge Variations in Rangmati Basin during different Scenarios (1961-2000, 2046-2064, 2081-2100)

Water Balance Component for Overall Scenario (1961-2000, 2046-2064, 2081-2100)

The average of mean seasonal and annual water balance component presented in Figure 7, and it showed that the seasonal rainfall, seasonal runoff, seasonal groundwater recharge and seasonal evapotranspiration was found increasing at 75.65 mm/decade, 47.32 mm/decade, 10.91 mm/decade and 12.10 mm/decade, respectively while seasonal potential evapotranspiration and annual potential evapotranspiration was found as decreasing at 4.76 mm/decade and 2.71 mm/decade, respectively.

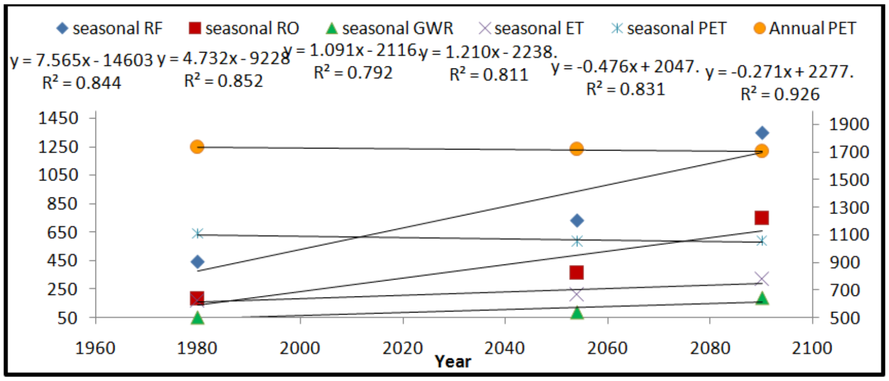

Figure 7: Comparison of Trend of Scenario avg. of Mean Seasonal and Annual Water Balance Component for Rangmati Basin

CONCLUSIONS

This study will help prepare a future plan for the water resources development and management for the basin. The seasonal rainfall, seasonal runoff, seasonal groundwater recharge and seasonal evapotranspiration were found increasing in trend, while seasonal potential evapotranspiration and annual potential evapotranspiration was found as decreasing trend. The decrease in the potential evapotranspiration and increase in the crop evapotranspiration may be due the increase in the rainfall.

ACKNOWLEDGEMENTS

The author is highly acknowledged to Bhaskaracharya Institute for Space Application and Geo- Informatics (BISAG), Gandhinagar, State Water Data Centre (SWDC), Gandhinagar and Millet Research station, JAU, Jamnagar for extending help in data procurements.

REFERENCES

1. *Arnold, J.G., Moriasi, D.N., Gassman, P.W., Abbaspour, K.C., White, M.J., Srinivasan, R., Santhi, C., Harmel, R.D., Griensven, A. V., Van Liew, M.W., Kannan, N. and Jha, M.K. (2012). SWAT: Model use, calibration, and validation. Trans. ASABE. 55(4):1491-1508.*
2. *Das, S. and Prakash, I. (2008). Assessment of groundwater hazards in a coastal district of Gujarat, India. In: 6th international conference on case histories in geotechnical engineering, Arlington.VA, august 11-16, 2008*
3. *Dile, Y. T. and Srinivasan, R. (2014). Evaluation of CFSR climate data for hydrologic prediction in data-scarce watersheds: an application in the Blue Nile River Basin. Journal of the American Water Resources Association (JAWRA) 1-16.*
4. *Fuka, D.R., MacAllister, C.A., Degaetano, A.T. and Z.M. Easton. (2013). Using the Climate Forecast System Reanalysis dataset to improve weather input data for watershed models. Hydrol. Proc.*
5. *Gassman, P.W., Reyes, M.R., Green, C.H. and Arnold J.G. (2007). The Soil and Water Assessment Tool: Historical development, applications, and future research directions. Trans. ASABE. 50(4):1211-1250.*
6. *Luzio, D.M., Srinivasan, R. and Jeffrey, G. A. (2002). Integration of watershed tools and swat model into basins. Journal of the American Water Resources Association (JAWRA). 38(4):1127-1141.*
7. *Micheal, A.M. 2010. Irrigation Theory and Practice. Second Edition. Vikas Publishing House Pvt. Ltd.:4-8.*